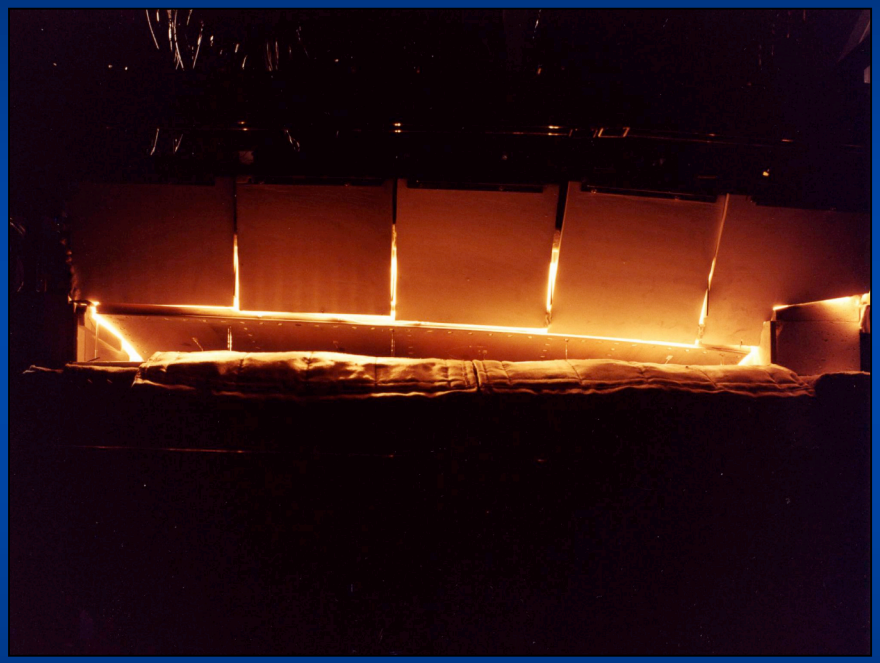
NASA Dryden Flight Loads Laboratory



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Edwards, CA
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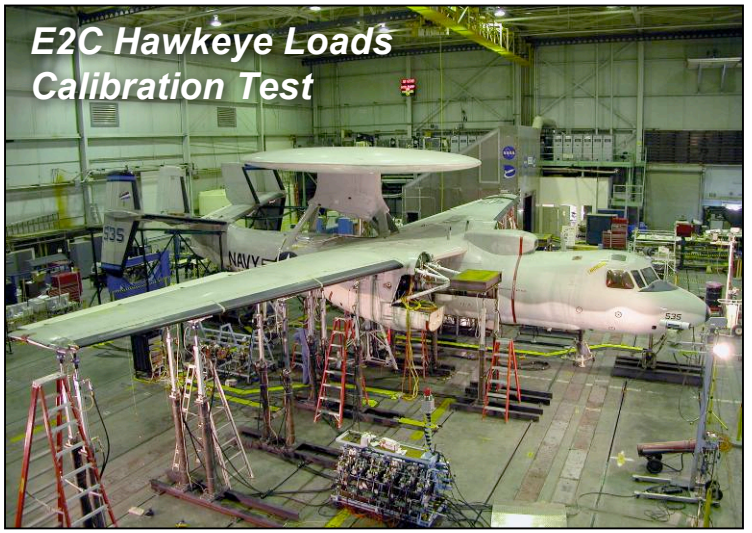
NASA Dryden's Flight Loads Laboratory

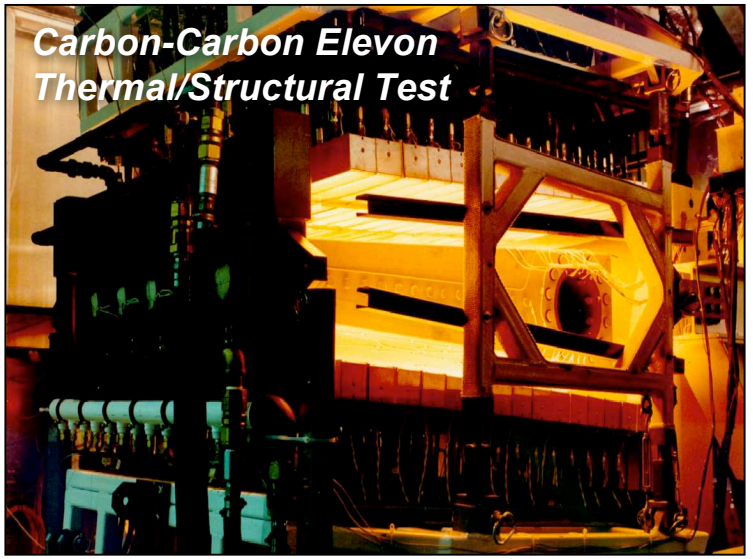
Flight Loads Lab Capabilities and Research Interests
Experienced Engineering and Technical Workforce

- **Structural, thermal, & dynamic analysis**
  - Finite-element analysis (FEA)
  - Aerodynamic loads analysis (CFD)
  - Flutter analysis
  - Aeroservoelastic analysis (ASE)
  - Aeroheating / heat transfer analysis
- **Structural, thermal, & dynamic ground-test techniques**
  - Structural loads calibration and equation derivation
  - Proof loads testing
  - Ground vibration and structural mode interaction testing
  - Thermal / structural testing
- **Advanced structural instrumentation**
  - Strain, temperature, heat flux, deflection, etc.
  - Fiber-optic strain and temperature sensors
- **Flight test support**
  - Flight test planning
  - Structural and thermal flight data analysis

Flight Loads Lab Capabilities
Overview

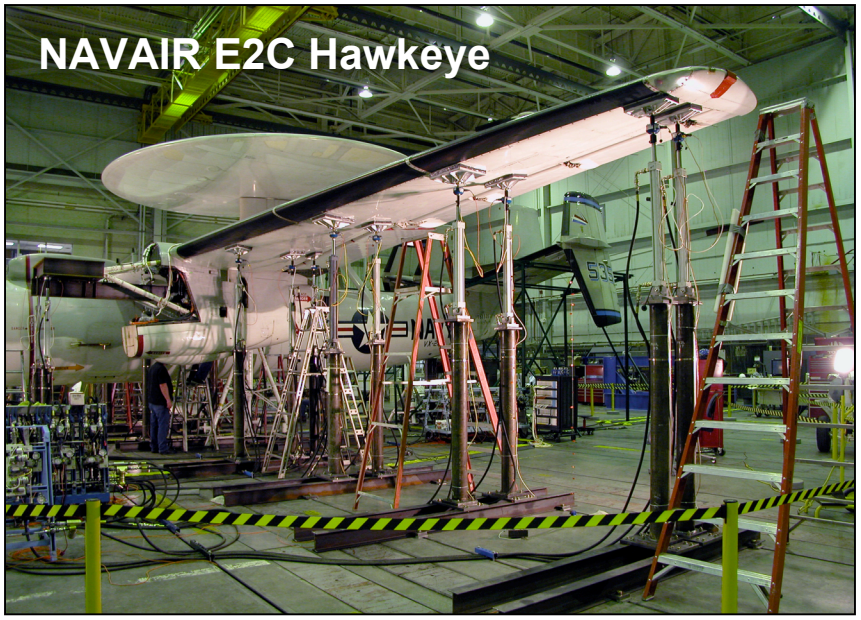
- **General Description**
  - A unique laboratory for structural and thermal testing of aerospace structures
  - Large 164’ x 120’ high-bay test area
- **Structural Loading Capabilities**
  - Structural loading equipment including load frames, load cells, and hydraulic actuators
  - 84 channels of hydraulic load control
  - Aircraft ground vibration and structural mode interaction testing
- **Thermal Loading Capabilities**
  - Quartz lamp and graphite element heating
  - Vacuum furnaces, low and high temperature chambers, liquid and gaseous nitrogen supply systems
  - 4000 gal of liquid nitrogen storage for cryogenic testing
- **Structural Evaluation Systems**
  - Infrared Pulsed Thermography for NDE
  - Photogrammetry for Strain and 3D Deformation
  - Acoustic Emission Sensing for Damage Detection
- **Data Acquisition and Control System**
  - 1280 channels of data acquisition
  - 108 channels of thermal control (expandable to 512)


E2C Hawkeye Loads Calibration Test


Carbon-Carbon Elevon Thermal/Structural Test

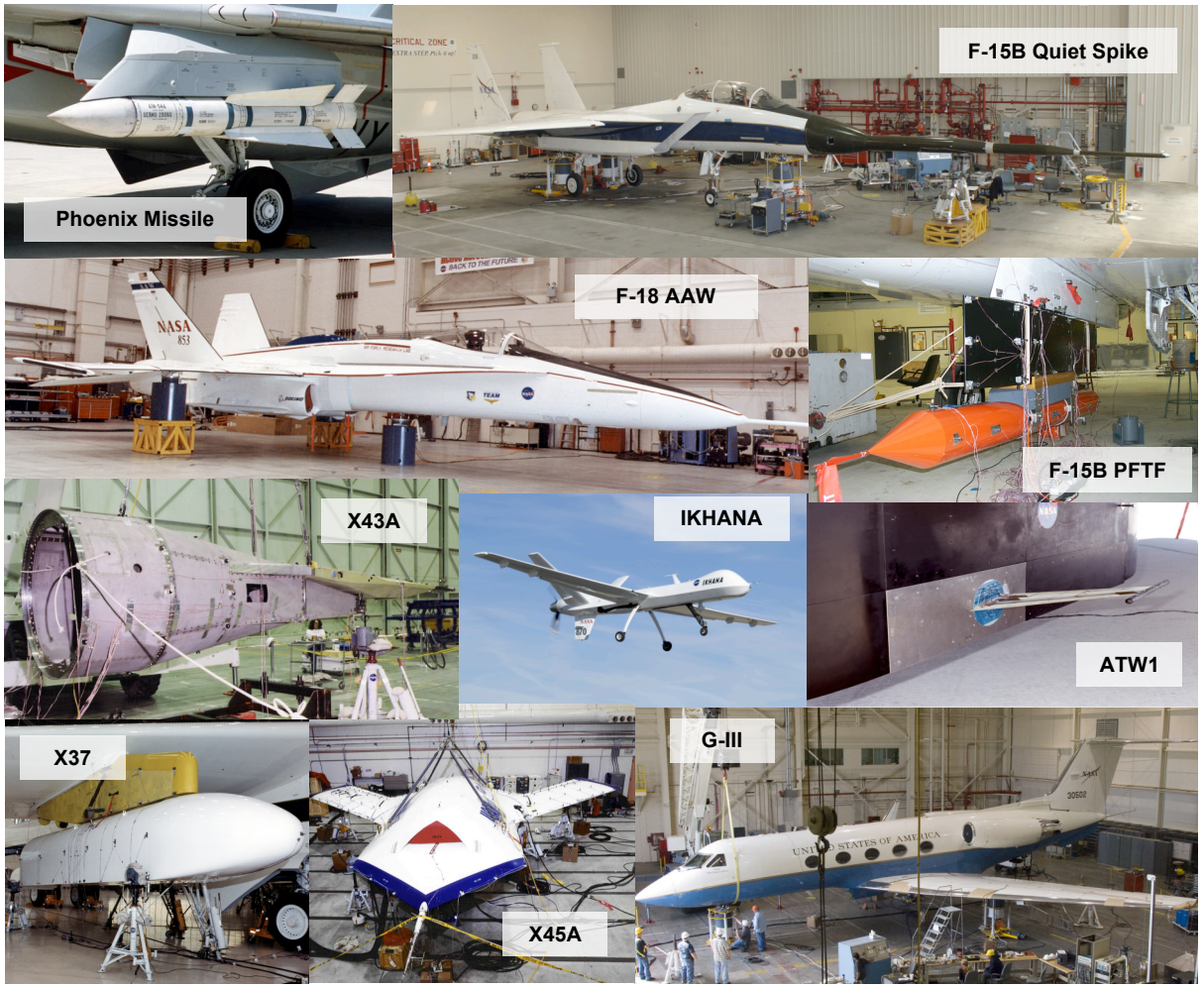
Flight Loads Lab Capabilities
Loads Calibration Testing

- Loads calibration testing of large aircraft and structures
- Application of realistic pressure load distributions
- Derive load equations for real-time determination of in-flight loads



Flight Loads Lab Capabilities
Ground Vibration Testing

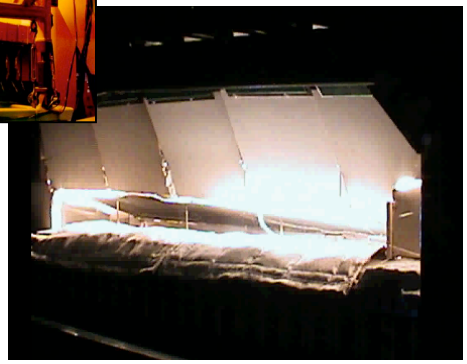
- Ground vibration testing of flight vehicles and structures
- Determination of structural mode shapes, natural frequencies and damping
- Supports FEM validation and provides data to update FEM as required
- Soft-support system capable of testing structures up 60k lbf structure



Flight Loads Lab Capabilities
Combined Thermal / Structural / Cryogenic Loading


Shuttle Elevon Seal Test

- Flight environment can be simulated through cooling, heating and structural load application
- Hydraulic actuators and load cells with capacities up to 300,000 lbf
- Temperature Range: -320°F to >3000°F
  Temperature Rise Rate: ≈150°F/sec max
  Heating Rate: ≈100 Btu/ft^2-sec

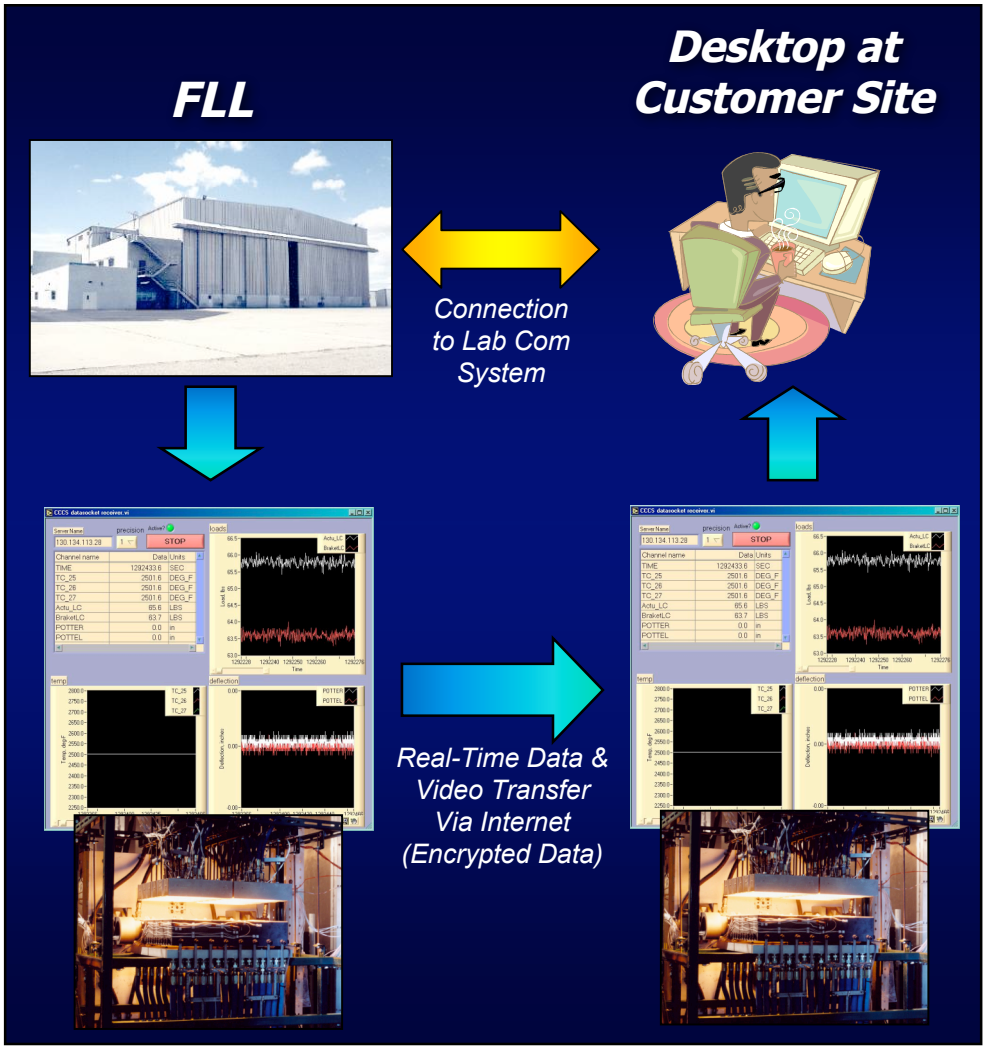


Hot Structures Testing


Thermal / Cryo Testing with Mechanical Loading

Flight Loads Lab Capabilities
"Virtual Flight Loads Lab"

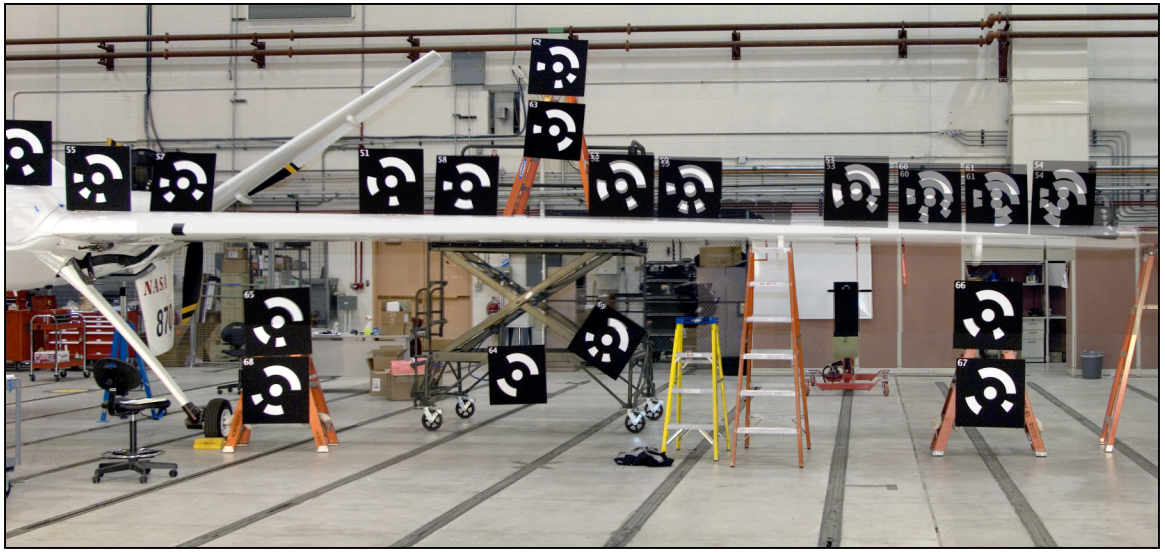
- Real-time remote access to data, video and com system
- Customer control of data and video
- 128 bit data encryption
- Maximizes customer participation and reduces need to travel

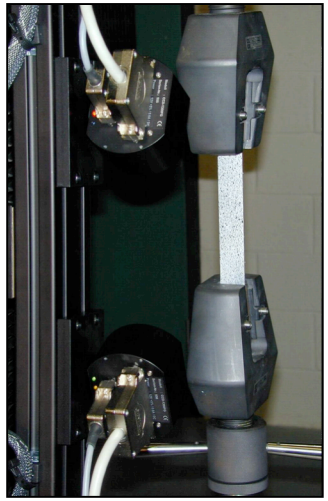


Flight Loads Lab Capabilities

Photogrammetry for Measuring Strains and 3D Deformations

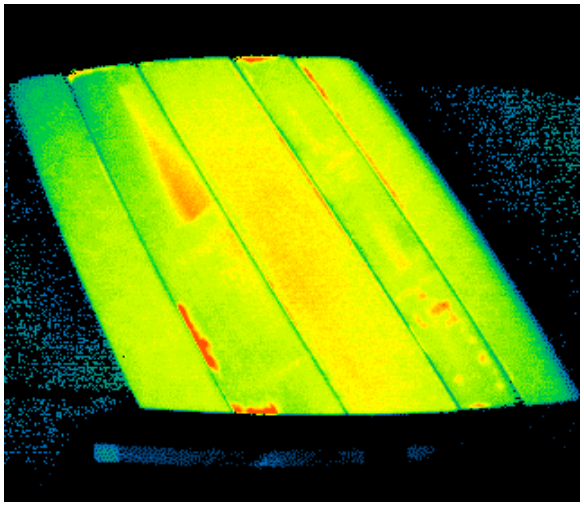
- Optical technique for measuring strains and spatial deformations
- High-speed cameras for dynamic testing
- Coupon specimens to large aircraft

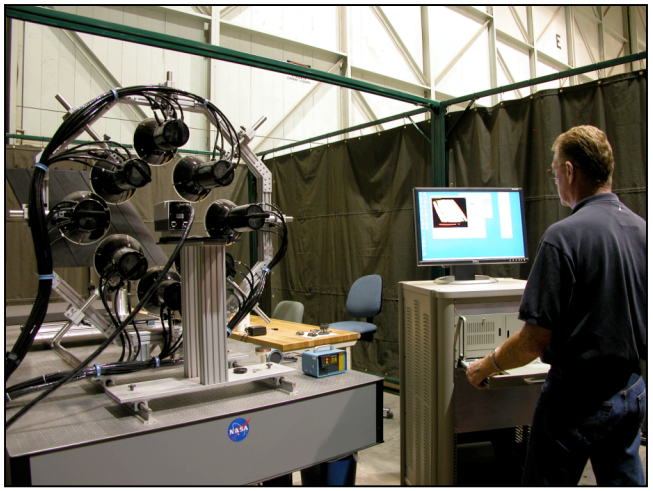


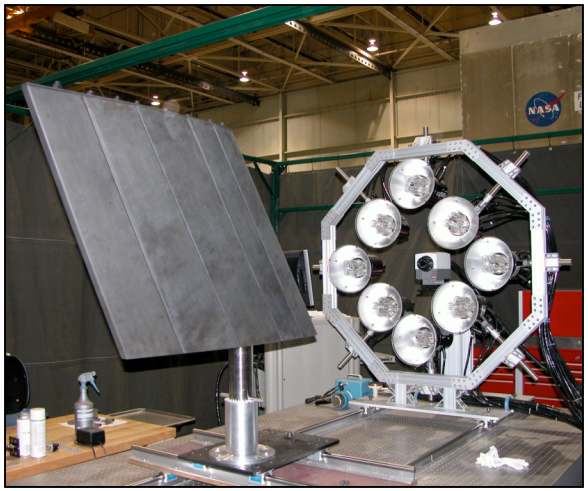


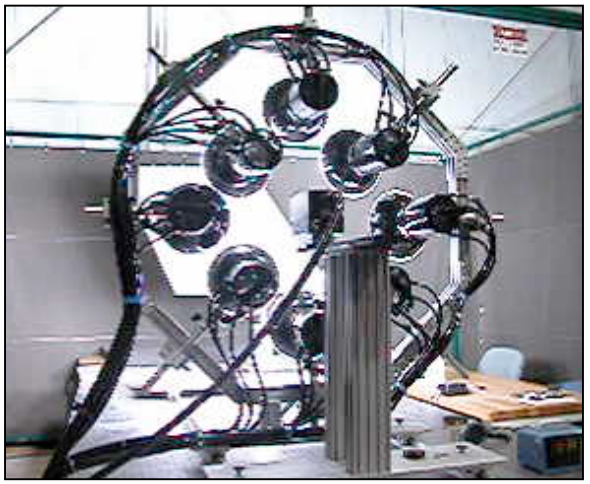
Flight Loads Lab Capabilities
Non-Destructive Evaluation

- NDE of structural components using Infra-red Pulsed Thermography
- Locates and maps delaminations and porosity
- Locates precise depth of defect



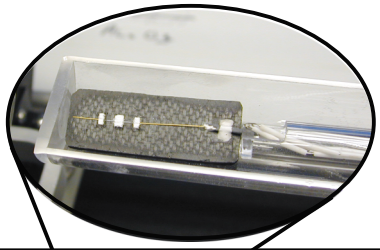
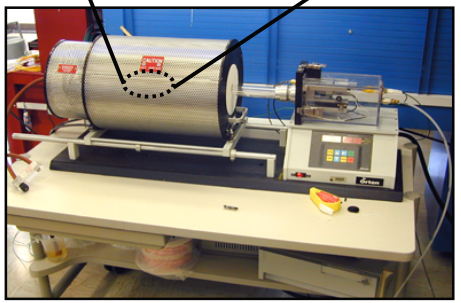
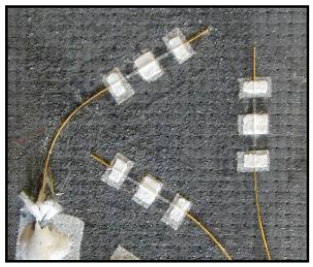


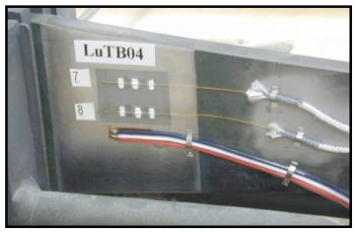
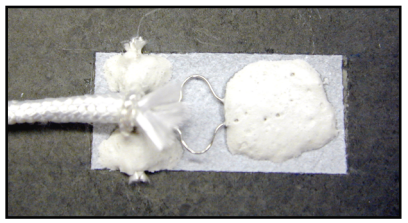
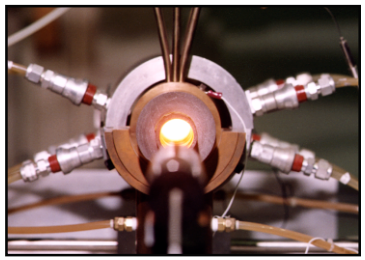
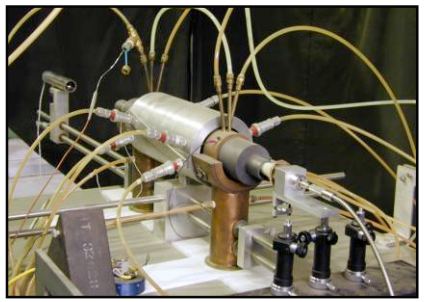




Flight Loads Lab Capabilities
Advanced Structural Instrumentation

- **Strain, temperature, heat flux measurements on advanced materials including:**
  - Metallics, metal matrix composites, superalloy honeycomb, C/C and C/SiC
- **Sensor evaluation and calibration systems**
  - Strain sensors from -320°F to 3000°F
  - Temperature sensors from -320°F to 4000°F
  - Heat flux gages to 400 Btu/ft^2-sec
- **Attachment techniques**
  - Epoxy based adhesives
  - Ceramic & graphite cements
  - Plasma and Rokide thermal spraying
- **Advanced sensor application research**
  - Fiber-optic strain and temperature
  - Ground and flight testing

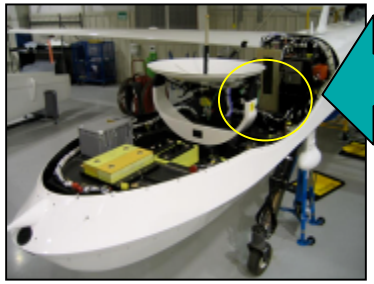





Ikhana Fiber Optic Flight System

- Current flight system specifications
  - Fiber count: 4
  - Max fiber length: 40 ft
  - Max sensing length: 20 ft
  - Max sensors / fiber: 480
  - Total sensors / system: 1920
  - Sample rate: 2 fibers @ 36 sps
    4 fibers @ 22 sps
  - Power: 28VDC @ 4 Amps
  - User Interface: Ethernet
  - Weight: 23 lbs
  - Size: 7.5 x 13 x 13 in
- Environmental qualification specifications
  - Shock: 8g
  - Vibration: 1.1 g-peak sinusoidal curve
  - Altitude: 60kft at -56C for 60 min
  - Temperature: -56 < T < 40C

Fiber Optic Flight System



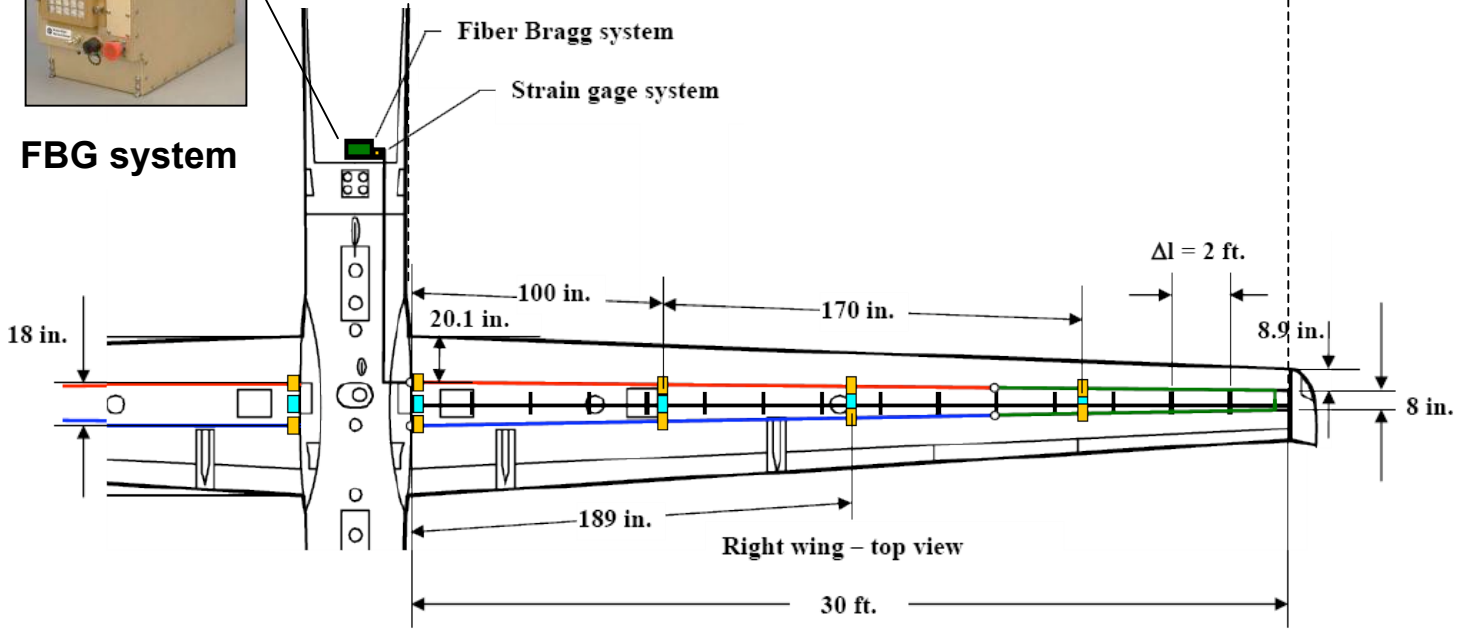
Ikhana Avionics Bay

Flight Instrumentation

- Instrumentation
  - 2880 FBG strain sensors (1920 recorded at one time)
  - 1440 FBG sensors per wing
  - Select optimal number of FBG sensors for real-time wing shape sensing
  - 16 strain gages for FBG sensor validation
  - 8 thermocouples for strain sensor error corrections

Strain gage system

FBG system



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